

Zero Retries issue 0008 2021-09-03

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New Paradigm Network Amateur Radios - Part 2

This issue continues the discussion begun in Zero Retries 0007 - **New Paradigm Network Amateur Radios - Part 1 - Software Defined Receivers, Transceivers, and GNU Radio.**

Here are, what I see as other “near term, kind-of-easy-to-implement” options for New Paradigm (High Speed) Network Amateur Radios. I list them below in order of (my perception of) feasibility:

- Use VARA FM with Existing Audio Interfaces and Radios.
- Use AREDN Radios to Create Mesh Networks (Microwave Frequencies).
- Use HamWAN and / or Part 15 Radios to Create Fixed-link Networks (Microwave Frequencies).
- Productize New Packet Radio into an Integrated Unit.
- Create / Modify Amateur Radio 2.4 GHz Power Amplifiers for 2.3 GHz AREDN Radios.
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- Create RAMA.

Use VARA FM with Existing Audio Interfaces and Radios

As discussed in Zero Retries 0004 (VARA FM Deep Dive) and Zero Retries 0006 (VARA FM Deep Dive, Part 2), use existing radios with flat audio input, combined with high fidelity audio interfaces, with [VARA FM software](#). VARA FM can do reliable data transfer at up to 25 kbps. The required radios, audio interfaces, and VARA FM are all available “off the shelf” and thus no additional development is required (or possible, given that VARA FM is proprietary software).

Use AREDN Radios to Create Mesh Networks (Microwave Frequencies)



(Logo courtesy of AREDN)

AREDN will receive a future “full issue” treatment in Zero Retries. I’ve written previously about AREDN - [More on Using AREDN](#), but I’ve learned a lot since that article.

Like VARA FM, [Amateur Radio Emergency Data Network \(AREDN\)](#) radios are available “off the shelf”, thus you can begin using AREDN now to build higher speed Amateur Radio Networks. Because they automatically connect with any other AREDN radio within range (assuming compatible parameters - channel, channel size, etc.) it’s easy to build an AREDN network. But, because AREDN radios operate at 2.3 GHz (or higher frequencies) and relatively low power, it’s tough create networks that span more than a mile or so, and especially trees, unless there is clear line of sight between AREDN units, such as making use of mountaintops or buildings or towers to locate relay nodes. Directional antennas can also help to create longer range, more reliable links. AREDN has good documentation, support forums, and they do a good job of [listing known good hardware to use](#). Installation and use of AREDN can be a bit intimidating for newcomers, but the basics are easily learned and local mentoring can help a lot. One nuance that favors AREDN as Amateur Radio networking is that the radios are physically indistinguishable from those used by Wireless Internet Service Providers (WISPs) to provide Broadband Internet Access. Thus, condominium and apartments cannot restrict the use of such units thanks to the [FCC’s updated Over The Air Reception Devices \(OTARD\) regulations](#).

Use HamWAN and / or Part 15 Radios to Create Fixed-link Networks (Microwave Frequencies)



(Logo courtesy of HamWAN)

In contrast to AREDN’s automatic mesh networking, [HamWAN](#) is an engineered, architected network that uses 5.8 GHz (Part 15) radios between nodes, and 5.9 GHz (Part 97) for user access to nodes. You have to know where the (high level) HamWAN nodes are, aim your user radio at them with a tight beam, and you must have a clear (optical) line of sight between the user radio and the node. If there’s no HamWAN node, it’s difficult to “casually create one” as HamWAN nodes are built to be reliable, manageable, and standardized per HamWAN’s carefully developed standards. That said, there are [HamWAN systems in various parts of the country](#), following the standards that were prototyped, tested, and developed in the first HamWAN system, the Puget Sound Data Ring (PSDR) in Western Washington.

Much like HamWAN networks, it’s also possible to build engineered, architected wireless networks that use 5.8 GHz (Part 15) radios for both node-to-node communications, and user access. There is ample, and good, Wireless ISP equipment from vendors such as [Ubiquiti](#), [MikroTik](#), and [Cambium Networks](#). Some products from Ubiquiti and MikroTik are modified for use in AREDN and HamWAN, but you don’t have to do so to make effective use of them in building a microwave network. Because these products largely operate in license-exempt spectrum, anyone can buy them and create networks with them. The most notable “Amateur Radio” network using license-exempt devices is [Highspeed Amateur radio Multimedia NETWORK \(HAMNET\)](#) in Europe.

Note that the FCC [recently decided](#) that 5.9 GHz is no longer “exclusive” to Amateur Radio operations.

Productize New Packet Radio Into an Integrated Unit



(Photo courtesy of Hackaday.com)

New Packet Radio will also receive a future “full issue” treatment in Zero Retries.

[New Packet Radio](#) (NPR) is the epitome of a successful Open Source New Paradigm Network Amateur Radio. The creator of NPR, Guillaume F4HDK [worked on this project for six years](#) and NPR was announced in 2019-10. F4HDK has done a stellar job of designing an open source system - hardware, firmware, code, etc. Most importantly, NPR is the rare Open Source project with *great documentation!* The proof of NPR’s well-thought-out design and fully open source approach is that several “forks” of NPR hardware have been created besides the official NPR hardware available from [ELEKITSORPARTS](#). NPR data speeds are up to 500 kbps in a 100 kHz channel on 440-450 MHz, which is legal in Europe. In the US, *archaic Part 97 rules* specify the maximum data rate at 440 MHz is “56 kbps” which NPR grudgingly accommodates... *with the same channel size... why would you want to have a slower data rate than the maximum data rate the hardware is capable of?*

I’m aware of a group of NPR users in California, and a few other individual experimenters like me, but of late, the [mailing list for NPR in the US](#) is pretty quiet.

I feel that the primary issue to wide adoption in the US is that sourcing the components of NPR is something of a treasure hunt. ELEKITSORPARTS, the official supplier of commercial NPR units is in Europe, so it’s mildly daunting to order from them. The transmit power from the NPR radio is 0.5 watts, but a specific power amplifier intended for Digital Mobile Radio (DMR) portables is recommended that provides transmit power level of approximately 20 watts. When I was buying my NPR units, the recommended amplifier was hard to obtain and there were many look-alike units. Cobbling together different pieces of equipment feels a bit like a (fun) science experiment, and that isn’t attractive to some data-oriented Amateur Radio Operators who would prefer to “just buy a single box” rather than integrating (and troubleshooting) multiple units. I suspect that there would be wider adoption of NPR if there was an integrated NPR radio offered for sale that incorporated the NPR radio and the power amplifier in a single chassis. Given the completely open source design, including all hardware details, it should be possible to create such an integrated unit. Localino in Germany offers [their own version of the NPR Radio \(NPR-H\)](#) and a [companion power amplifier for NPR-H](#) that provides 6.3 watts transmit power.

I think that if a New Packet Radio system was packaged into a single unit with 20-25 watts output power, and sold for \$300 or less, it would appeal to a larger market of those who want to experiment with higher speed data modes in Amateur Radio, but would rather experiment in the software and networking realm, rather than “fuss with radios”.

Create / Modify Amateur Radio 2.4 GHz Power Amplifiers for 2.3 GHz AREDN Radios

Amateur Radio Operators in Europe have access to [Es’hail 2 / QO-100](#) - an Amateur Radio “payload” on a geostationary satellite with coverage over Europe, Asia, and Africa. The uplink to Es’hail 2 / QO-100 is on 2.4 GHz. Given that it’s 22,300 miles away, some reasonable transmit power is required, significantly above the minuscule power levels of typical 2.4 GHz consumer devices. That requirement for additional transmit power overlaps nicely with the minuscule power levels available from repurposed Wi-Fi units repurposed with new firmware for AREDN use, operating on 2.3 GHz. How much better would AREDN nodes (especially high level AREDN nodes) work if they could transmit at, for example, 5 watts? Amateur Radio 2.4 GHz amplifiers (designed for 2.40 - 2.45 GHz) for Es’hail 2 / QO-100 include:

- [E-REON 2.4 GHz 2W amplifier for QO-100](#) (2 watts)
- [AMSAT UK 5 watt 2.4 GHz Amplifier Kit for QO-100](#) (5 watts)
- [SG Laboratory Ltd Power amplifier for 2.4GHz up link Es'Hail 2 satellite](#) (20 watts)
- [E-REON 2.4 GHz 30W PowerBlast amplifier](#) (30 watts)

It’s notable that the SG Laboratory unit is specified to operate from 2.38 GHz through 2.450 GHz. That nicely encompasses the AREDN “-2” channel (5 MHz - 2.937 - 2.402 GHz) and AREDN “-1” channel (5 MHz - 2.403 - 2.407 GHz). The AREDN default is “-1” with a 10 MHz channel (2.937 - 2.407 GHz). Thus no modification would be required (except perhaps some attenuation between the AREDN unit and the amplifier to not exceed the maximum input power to the amplifier).

Create a Driver Amplifier Compatible with Software Defined Transceivers

The details of this were discussed in Zero Retries 0007 in the article **Software Defined Transceivers... We Got Those Too! More Low Hanging Fruit**. Basically, while Software Defined Transceivers already exist, their power levels are too low for actual use in Amateur Radio. What is needed is a “driver amplifier” that has an input stages compatible with the *very low power output* of Software Defined Transceivers, and output power level compatible with the input stages of existing power amplifiers.

Create RAMA

I outlined RAMA in Zero Retries 0006 - basically, RAMA would be an “audio interface mode” that uses existing Amateur Radio VHF / UHF radios and audio interfaces, to provide equivalent (or better) capability versus the proprietary VARA FM software.

The goal of RAMA is to achieve robust, high speed (25 kbps or faster) data communications mode over VHF / UHF in a normal 20 kHz FM channel.

A reader pointed out that RAMA could potentially be developed “quickly” as a distributed open source project because it’s “software only” and operates purely in the the audio domain. Thus it could easily be tested using nearly any audio interface, including audio distributed via Internet applications and even remotely controlled radios to get real world experience. For example, I could set up multiple test systems that include a Raspberry Pi computer, high fidelity audio interface, and a radio. I could allow remote access to these systems to developers of RAMA to remotely download and test their software in real world conditions, without the developers needing physical access to radios.

To be Continued...

The Substack editor informs me that I’m close to overflowing the allowable amount of text for this issue of Zero Retries. Thus, this discussion will continue next week in Zero Retries 0009 - New Paradigm Network Amateur Radios - Part 3.

Feedback Loop

[Redditor GDK_ATL](#) (comment) 2021-08-04 regarding Zero Retries 0000

ZR: Amateur Radio isn't much more socially relevant than blacksmithing is to modern manufacturing

Socially relevant! Who cares how socially relevant it is? Fly fishing, golf, knitting, softball, ping pong, biking, running, curling, gymnastics, swimming, and on and on, how socially relevant are those? Maybe too many people just want a hobby that facilitates their virtue signaling on social media.

GTK_ATL - The *social relevance* of Amateur Radio *matters* because it uses a public resource, as in the spectrum Amateur Radio is allocated. If Amateur Radio isn't socially relevant, it won't be allowed to continue to use the public resources of spectrum.

Redditor arkhynchul (same thread as above)

author really should say "USA amateur radio" instead of just "amateur radio".

arkhynchul - You're right, now so disclaimed (see below). That said, I hope that Zero Retries eventually finds an audience outside the US, and non US Amateur Radio Operators can contribute their perspective.

John Grumling K0JEG comment on Substack regarding Zero Retries 0006

I would add a possible full duplex repeater mode, similar to how a DOCSIS cable modem operates. Cable modems (CM) only communicate with a specialized router known as a Cable Modem Termination System (CMTS). The CMTS downstream carrier imbeds data describing how and when a CM can communicate to establish communications. This data includes transmit frequencies, modulation types supported and TDMA timing sync data. Some of the TDMA time slots are reserved for "ranging" opportunities, similar to a net controller calling out for any station who wants to call in now. Once a modem is heard from the CMTS will allocate a "mini slot" for that CM and begin fine tuning the timing, modulation and transmit power level. When the CMTS and CM reach détente (usually a few seconds) the data-specific and authentication data is exchanged, and the CM will start passing data to the customer equipment. Note that operators will offer several upstream (and downstream) modulation formats to allow for older modems and cable craft issues, etc.

The repeater could periodically advertise frequencies it is listening on and when to transmit. This would allow for cross-banding on many different bands, such as 1.2 GHz and 222 MHz but also allow for 2M/70CM users to get their feet wet, possibly at lower transmit speed, and modulation handshaking for weaker signals while optimizing the repeater output channel with higher modulation rates, assuming a high power amplifier would be installed, optimized location and antenna systems, etc. While automating the handshake process is probably a little too much take on for amateurs, by baking in cross-band and separating RF input from RF output from the start it opens the door to the possibility down the road.

K0JEG - This sounds like a fascinating area of research! I note that many HF software defined radios are using chips originally designed for cable modems. Perhaps the cable modem protocols *could* be adapted for Amateur Radio.

Larry Gadallah NM7A regarding Zero Retries 0007

I wish you had emphasized the open source end of things, as we discussed before; i.e. the Flex-Radio, the Icoms, and quite a few other "SDRs" don't qualify because you and I, as users of those radios, don't have any practical way to change the software and in turn make the radios "software defined".

NM7A documents his concerns about "Software Defined" Radio more thoroughly in his blog post [Whither SDR?](#)

NM7A - You are, of course, correct. In Amateur Radio, it hardly counts as "Software Defined" if it's not open enough to be "re-defined" by the user. I have some mild sympathy for Flex Radio no longer embracing open source. Flex Radio's first product, the [SDR-1000](#) was open source, and hardware was made by other entities. Flex became the default support for software (and non-Flex hardware) support issues, even though Flex Radio had nothing to do with hardware other than their own. Those issues, and their pivot to begin manufacturing government and commercial products, were a reasonable reason to not continue with open source. I recently read (or heard, in an interview) that Flex Radio maintains a very robust set of Application Programming Interfaces for their current software. That's certainly not open source, but it's something.

Phil Karn KA9Q comment on Substack regarding Zero Retries 0007:

Take a look at my paper for the upcoming DCC: <http://www.ka9q.net/KA9Q-radio.pdf>. I argue that it's the protocols and interfaces between the various modules that really matter. Having not seen a whole lot of discussion of the topic, I argue for IP multicasting.

KA9Q - Your ideas are always fascinating! As usual with one of your papers, it takes me several passes to really absorb, but you're right - decoding once and multicasting to other systems or processes makes a lot of sense.

John Grumling K0JEG comment on Substack regarding Zero Retries 0007

What ever happened to Bruce Perens' (K6BP) white box radio? IIRC he was coming up with a reference design for an open source digital voice radio. Seems like it should be more possible than ever now that FPGAs are fairly cheap and manufacturers have fairly stable architecture and programming. I think if we want radios such as you describe it will be up to the ham community to develop the spec and publish it. Then manufacturers could just crank out boxes without having to devote a lot of resources to engineering. Of course that was what JARL did with D-star and look how that turned out. Who knew by publishing the spec in Japanese it magically became closed and proprietary to Icom... 🙄

At any rate, I have a Lime SDR mini, LimeNET Micro and two Lime RFE amplifiers. The RFE was delayed for nearly two years due to COVID and the end of production of the main PA chip. They had to completely redesign the amp for a new chip. Seems like this a pretty common problem with RF devices. The LimeNET Micro is the most interesting of the set, since it is designed around a Raspberry Pi Compute Module 3. Basically it is a complete SDR computer, just plug in a monitor, keyboard, sound card and mouse. It also has USB, wifi and Ethernet onboard, opening up possibilities for a "network attached radio." But the learning curve for all that is huge and the delay in the RFE meant it got pushed to the back of the workbench.

I've played around with generating different modulation and hearing tones on a receiver, but the learning curve for GNU radio is enormous even using the GUI companion software. Scratch radio is better but it still needs to be built from source. A reference design for a carrier board around a Raspberry PI 4 compute module, SDR, 5 Watt PA and power/battery charging seems like it should be attainable, along with a prebuilt image for the Pi, preferably one that is maintained long term. All of the network interface stuff is already on the RPI, the GPIO is well understood, and GNU radio runs on a 3B, so it should really shine on a 4. A stripped down custom image with set up scripts to get a base configuration would complete the radio. Heck, if done right it could even make it through the FCC part 15 scanner requirement.

K0JEG - I don't know what became of the [Whitebox Radio Project](#). I have a vague memory that it was abandoned as the concept was slightly too advanced for the technology of the time. Perhaps it could be revived now that [ARDC exists to fund interesting projects](#), and perhaps [Open Research Institute could be a fiscal sponsor of the project](#). I concur with your other points.

John Gilmore W0GNU regarding "A Brief, Imperfect Specification for RAMA" in Zero Retries 0006:

Add to RAMA specs: Should interoperate with VARA FM over the air, using at least one modulation, ideally many. (Start with the simplest one you can find.)

Also, I recommend that anyone who has obtained the VARA software and has agreed to its license, should not write code for RAMA, due to some influential court cases about copyright and reverse engineering. But, the people who have VARA software should contribute by publicly documenting what VARA is doing, including its user interface, its capabilities, what libraries it uses, what files are included with it, its modulation techniques, and answering questions from RAMA experimenters. You use two parties: One who has the thing you want to reverse engineer, one who doesn't; and the transfer of information is by one writing original text to the other (not copying any of it out of the software).

There is no way that the VARA FM license can prevent someone who has never seen the software nor agreed to the license, from observing its transmissions, or from sending test transmissions to a VARA FM site and seeing how it reacts to them. This is the essence of black-box reverse engineering. I did just this to reverse-engineer the Unix UUCP software, many years ago.

I also think it would help to understand whether RAMA should be a modulation technique for sending packets (like IPv4 or IPv6 packets) over the air (and leaving higher level protocols like file transfers or email to some other software), or should be a "file transfer application" that integrates both the modulations and the capability to move files around, and/or something else. Keep it simple, or as simple as you can when trying to be compatible with something that probably grew in capabilities over time.

W0GNU - Thanks for your well-considered suggestions. If RAMA does become a real project, those points will be included.

Closing The Channel

A commenter in Reddit pointed out that I should disclaim that the views I express in about Amateur Radio in Zero Retries are mostly about Amateur Radio in the US. That comment is correct, thus consider it disclaimed that Zero Retries has a US-centric perspective of Amateur Radio. I do my best to think of "rest of world" Amateur Radio in my writing, but I'm not there in other parts of the world, so if I say something blatantly inaccurate, please call me out.

If you're enjoying Zero Retries, please tell your friends and co-conspirators. For the immediate future, Zero Retries will remain an experiment in progress. Feedback is easy if you're reading Zero Retries in email - just hit Reply and I'll get your email. Or you can go to the web version of any Zero Retries issue, scroll to the bottom, and post a comment on the web version of a Zero Retries issue. I'm especially interested in content ideas about things that you'd like to see discussed in Zero Retries. If you know of "Zero Retries Interesting" projects, groups, activities, etc. please let me know. I do reply to every Zero Retries email I receive.

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All previous issues of Zero Retries are available without restriction (no paywalls). For some background on Zero Retries, Issue 0000 was The Introduction Issue.

Thanks for reading!
Steve Stroh N8GNJ
Bellingham, Washington, USA
2021-09-03

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Below is a much more complete "footer" that has evolved over 30+ issues of ZR.

Join the Fun on Amateur Radio

If you're not yet licensed as an Amateur Radio Operator, and would like to join the fun by *literally having a license to experiment with radio technology*, here are some pointers:

- **Ham Radio for Dummies** by Ward Silver N0AX is a great overview of Amateur Radio. N0AX is a gifted writer and HRFD is now in its [4th edition](#).
- My two favorite **YouTube** channels for a good overview of Amateur Radio are [AmateurLogic.TV](#). and [Ham Nation](#) (part of Ham Radio Crash Course). These folks just seem to have so much fun!
- [Radio Amateur Training Planning and Activities Committee \(RATPAC\)](#) offers weekly presentations on general Amateur Radio topics (Wednesdays) and emergency communications in Amateur Radio (Thursdays).
- Dan Romanchik KB6NU offers a free **No-Nonsense Study Guide** for the [Technician test](#) (PDF).
- [HamExam.org Amateur Radio Practice Exams](#) offers good **Flash Card and Practice Exams**.
- When you're ready to take an **Amateur Radio examination** (Tech, General, or Extra), W1MX - The MIT Amateur Radio Society offers [remote exams](#), free for students and youngsters. *There are apparently [many other remote exam options](#).*

Bonus - with an Amateur Radio license, you'll be [more attractive on dates](#) 😊

Closing the Channel

- In its mission to grow Amateur Radio and make it more relevant to society in the 2020s and beyond, Zero Retries is published via email and web, and is available to anyone at no cost. Zero Retries is proud *not to participate* in the Amateur Radio Publishing Industrial Complex!
- My ongoing Thanks to Tina Stroh KD7WSF for, well, *everything* and Bill Vodall W7NWP as *Zero Retries Instigator in Chief*.
- My ongoing Thanks to pseudostaffers [Dan Romanchik KB6NU](#) and [Jeff Davis KE9V](#) for continuing to spot, and write about “Zero Retries Interesting” type items, on their respective blogs, from Amateur Radio and beyond, that I don’t spot on my own.
- [Southgate Amateur Radio News](#) consistently surfaces “Zero Retries Interesting” stories.
- The [Substack email publishing platform](#) makes Zero Retries possible. I recommend it for publishing newsletters.

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More bits from Steve Stroh N8GNJ:

- [SuperPacket blog](#) - *Discussing new generations of Amateur Radio Data Communications - beyond Packet Radio (a precursor to Zero Retries)*
- [N8GNJ blog](#) - *Amateur Radio Station N8GNJ and the mad science experiments at N8GNJ Labs - Bellingham, Washington, USA*

Thanks for reading!

Steve Stroh N8GNJ (He / Him)

These bits were handcrafted in beautiful Bellingham, Washington, USA

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